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Configurations of Inter-organizational Knowledge Links: Does Spatial Embeddedness Still Matter?

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KNOBEN J. and OERLEMANS L. A. G. Configurations of inter-organizational knowledge links: does spatial embeddedness still matter?, *Regional Studies*. The actor composition of inter-organizational ego-networks is largely ignored in research on territorial innovation models. To fill this gap, this paper explores with which sets of external actors (that is, configurations) firms maintain inter-organizational knowledge links. Subsequently, it analyses the differences in innovative performance between firms engaged in different configurations, also taking into account their geographical dimensions. Four configurations emerged, all of which have positive effects on a firm's innovative performance in comparison with the 'go-at-it-alone' strategy. After controlling for actor composition and tie depth, however, their geographical composition is found to be unrelated to the innovative performance of firms.

Innovation   Configurations   Collaboration   Geographical proximity   Alliance portfolio   Portfolio diversity

KNOBEN J. and OERLEMANS L. A. G. 组织间知识关联的配置：空间是否仍然相关？区域研究。在关于领域创新模型的研究中，区域间组织网络行为者的构成往往被忽略。为了填补上述研究空白，本文考察了维持组织间知识关联外部要素有哪些。文章相应分析了不同公司创新行为之间的差异，同时将地理层面的要素纳入考虑范围。较之'独立'的策略而言，四种配置方式中每一种都对公司的创新行为产生积极影响。　然而，将行为者组成以及关联深度进行控制之后，（研究）发现，行为者的地理组成与公司创新行为不发生关联。

创新　配置　合作　地理毗邻　联盟组合　投资组合的多样性

KNOBEN J. et OERLEMANS L. A. G. Les configurations des chaînes inter-organisationnelles de la connaissance: est-ce que l'ancrage géographique importe toujours?, *Regional Studies*. En ce qui concerne la recherche sur les modèles d'innovation géographiques, on fait peu d'attention à la composition des acteurs des réseaux inter-organisationnels du moi. Afin de colmater cette brèche, cet article cherche à examiner les ensembles d'acteurs externes (c'est-à-dire, les configurations) avec lesquels les entreprises suscitent des chaînes inter-organisationnelles de la connaissance. Par la suite, on analyse la variation de la performance en matière d'innovation des entreprises qui s'engagent dans diverses configurations, en tenant compte aussi de leur étendue géographique. Il en ressort quatre configurations, dont tous les quatre ont des retombées positives sur la performance de l'entreprise en matière d'innovation par rapport à la stratégie de 'faire cavalier seul'. Cependant, ayant tenu compte de la composition des acteurs et de l'intensité du lien, il s'avère que leur composition géographique ne se rapporte pas à la performance en matière d'innovation des entreprises.

Innovation   Configurations   Collaboration   Proximité géographique   Portefeuille d'alliances   Diversification du portefeuille

KNOBEN J. und OERLEMANS L. A. G. Konfigurationen von interorganisationellen Wissensverknüpfungen: spielt die räumliche Einbettung noch eine Rolle?, *Regional Studies*. In den Studien über territoriale Innovationsmodelle wird die Zusammensetzung der Akteure in interorganisationellen Ego-Netzwerken weitgehend ignoriert. Um diese Lücke zu schließen, untersuchen wir in diesem Beitrag, mit welchen Gruppen von externen Akteuren (d. h. Konfigurationen) Firmen interorganisationelle Wissensverknüpfungen unterhalten. Anschließend analysieren wir die Unterschiede bei der innovativen Leistung verschiedener Firmen in unterschiedlichen Konfigurationen unter Berücksichtigung ihrer jeweiligen geografischen Dimensionen. Es ergeben sich vier Konfigurationen, die sich im Vergleich zur 'Einzelgänger'-Strategie alle positiv auf die innovative Leistung einer Firma auswirken. Bei einer Berücksichtigung der Zusammensetzung der Akteure sowie der Tiefe ihrer Verbindungen stellt sich jedoch heraus, dass ihre geografische Zusammensetzung in keinem Zusammenhang zur innovativen Leistung der Firmen steht.

Innovation   Konfigurationen   Zusammenarbeit   Geografische Nähe   Bündnisportfolio   Portfolio-Diversität

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KNOBEN J. y OERLEMANS L. A. G. Configuraciones de los enlaces de conocimiento interinstitucionales: ¿todavía importa la integración espacial?, *Regional Studies*. En los estudios sobre los modelos de innovación territorial se ignora en gran medida la composición de los actores de las ego-redes interinstitucionales. Para cubrir este vacío, en este artículo examinamos con qué grupo de actores externos (es decir, configuraciones) mantienen las empresas los enlaces de conocimiento interinstitucionales. Posteriormente, analizamos las diferencias en el rendimiento innovador entre las empresas que participan en configuraciones diferentes, considerando también sus dimensiones geográficas. Surgieron cuatro configuraciones, todas con efectos positivos en el rendimiento innovador de las empresas en comparación con la estrategia 'en solitario'. Sin embargo, después de tener en cuenta la composición de actores y la profundidad de los enlaces, observamos que su composición geográfica no está relacionada con el rendimiento innovador de las empresas.

Innovación Configuraciones Colaboración Proximidad geográfica Cartera de alianzas Diversidad de las carteras

JEL classifications: D83, L14, L25, O30

INTRODUCTION

There is a large body of literature arguing that the characteristics of a firm's regional environment explain why some firms are more innovative than others (for an overview, see MOULAERT and SEKIA, 2003). Many different concepts, such as clusters, innovative milieus, (regional) systems of innovation, industrial districts and learning regions, all grouped under the label 'territorial innovation models' (TIMs), have been introduced and studied to substantiate this claim both theoretically and empirically. Despite their differences, these concepts have in common that they strongly emphasize the importance of localized inter-organizational links for the innovativeness of firms (GORDON and MCCANN, 2000).

In the TIM literature, however, characteristics of these webs of inter-organizational links, such as external actor diversity and tie depth, are largely ignored (SACCHETTI, 2009). First and foremost, most studies on (regional) inter-organizational links tend either to neglect the type of actor with whom a link is maintained or to focus on dyadic relationships between a focal actor and, for example, a single supplier or university. This implies that often it is not taken into account that focal actors can be embedded in ego-networks,[1] which consist of sets of links with different actors possessing different knowledge sources and different relational characteristics. However, inter-organizational network research has shown that the structural and relational characteristics of these links and networks impact on the innovative outcomes of firms (POWELL *et al.*, 1996). Second, many of the empirical studies in this field are not built upon micro-level (that is, firm level) data but study the clustering of innovative activities at the meso (that is, the regional) level (BEUGELSDIJK, 2007). As a result, (localized) inter-organizational links are often not empirically observed (LEJPRAS and STEPHAN, 2008), but are assumed to exist when firms co-locate (DICKEN and MALMBERG, 2001). However, existing research has shown that this is not necessarily the case (SOHN, 2004) and that the patterns of interaction can widely differ between regions (CANTNER *et al.*, 2010). Third, many of the empirical TIM studies use case studies of (successful) localities and clusters as their research design (STEINER and PLODER, 2008) and therefore focus on inter-organizational links *within* one (or a few) regions (SACCHETTI, 2009). This is striking as an emerging body of work conceptually argues (BATHELT *et al.*, 2004; BOSCHMA, 2005) and empirically shows (GIULIANI, 2005; GRAF, 2011; IAMMARINO *et al.*, 2008; MORRISON, 2008; KNOBEN, 2009) that especially ties with organizations outside the home region are sources of new knowledge due to their 'weak tie' or 'global pipeline' nature. GIULIANI and BELL (2005), for example, found that some high-performing firms are only weakly connected to firms within their cluster but maintain strong links to extra-cluster organizations, thereby acting as a gatekeeper.

Based on the above it can be concluded that the empirical research regarding TIMs would benefit from more micro-level research that *simultaneously* takes the diversity in the types and depth of inter-organizational knowledge links (IOLs) as well as their level of localization into account. Therefore, this study puts forward a framework that emphasizes both geographical variety as well as external actor diversity and tie depth in IOLs. IOLs are defined as 'the links between a firm and external organizations with knowledge exchange or acquisition for its innovative activities as their primary goal.' The main argument developed and tested in this study is that firms are engaged in configurations of IOLs with different types of actors, with different tie depths (defined as the intensity with which firms draw resources from a particular type of actor), with different geographical scopes, resulting in different (innovative) outcomes (GOERZEN and BEAMISH, 2005). Therefore, the research questions are as follows. Which configurations of IOLs can be distinguished empirically; what role does the level of localization of actors play in these different configurations; and what are the differences in innovative performance of firms engaged in these different configurations?

Answering this research question contributes to the scarce micro-level TIM research in four ways:

- By providing a micro-view on actual IOLs instead of only assuming their existence.
- By taking into account that innovating firms are linked to sets of multiple actors and that these links vary on different dimensions (for example, depth, geographical scale).
- By introducing a configurational approach in the field of regional studies in which a level between dyads and whole networks is analysed; and in which relational (tie depth) and attribute (type of external actor) variables are combined in one approach.
- By including both local and non-local IOLs instead of focusing on local IOLs only.

This allows the relative importance of geographical proximity in IOLs to be assessed compared with the importance of the type of actor with whom the relation is maintained and tie depth. In short, this research provides a more realistic and valid picture of (the effects of) one of the main concepts of the TIM literature than provided by the existing empirical research.

To realize these contributions, the paper draws from different strands of literature. The reasoning on geographical variety is grounded in the regional and economic geography literature. More specifically, this study departs from one of the main assumptions in the Learning Region literature, namely that the localized interactive model of innovation is highly significant for regional development in general and innovation in particular (MORGAN, 1997; RUTTEN and BOEKEMA, 2007). The thinking on inter-organizational ego-networks is mainly developed in organization studies in which often a structural account is applied. This paper combines a structural account (actor diversity) with a relational account (tie depth). Lastly, it draws from an extended version of the resource-based view of the firm (LAVIE, 2006), in which it is argued that firms can derive competitive advantages from resources obtained through inter-organizational links.

Empirically, which configurations of IOLs exist is explored by applying a latent class cluster analysis to South African firm-level data. For this, IOL configurations are built consisting of direct knowledge links with different types of actors and with different tie depths in terms of the importance of the knowledge and information transferred. Subsequently, the differences in innovative performance between firms engaged in the different IOL configurations are analysed by also taking into account the variety in their geographical composition.

This paper is structured as follows. First, the theoretical relations between IOLs, innovation and geographical proximity are discussed. Subsequently, the concept of configurations of IOLs is briefly introduced, followed by a discussion of the data, measurements and methodology. Next, the results are presented and interpreted. Finally, the implications of this study are addressed, the limitations identified and directions for future research explored.

THE GEOGRAPHICAL DISTRIBUTION OF INTER-ORGANIZATIONAL KNOWLEDGE LINKS AND INNOVATION

The importance of IOLs for a firm's innovative performance has become more and more profound over time (OWEN-SMITH and POWELL, 2004). The notion that no innovating firm is an island, but needs resources and knowledge resources possessed or controlled by external actors, such as clients, suppliers, competitors, stakeholders, central and local public administration actors, and consultants, has been widely accepted. Through these external sources a firm gets access to additional or complementary resources and knowledge that are not available within its own organizational boundaries, which can lead to (innovative) advantages for the firm in question. The main argument behind this reasoning is a resource deficit perspective, in which innovating firms are forced to tap into external knowledge sources to produce innovations (LOVE and ROPER, 2001). In short, by pooling and sharing (complementary) resources, firms can collaboratively perform activities that neither of them could perform alone, and thereby overcoming resource-based constraints on performance (DYER, 1996).

In the literature on TIMs as well as in the IOL literature, an important influence is attributed to spatial distance between collaborating organizations (BOSCHMA, 2005; KNOBEN and OERLEMANS, 2006). The importance of the localization of IOLs lies in the fact that localization is assumed to facilitate face-to-face interactions (both planned and serendipitous) and trust-building, which foster the exchange of tacit knowledge and resources (TORRE and RALLET, 2005). Tacit knowledge, in turn, is often argued to be one of the main drivers of the innovativeness of firms because only tacit knowledge, as opposed to codified knowledge, is thought to contain truly new and hard-to-imitate insights (HOWELLS, 2002). The larger the geographical distance between actors, the more difficult it is to transfer tacit knowledge and, therefore, the more difficult it is to transfer resources that are truly conducive to the innovativeness of a firm. Consequently, firms with more localized IOLs would experience higher levels of innovative performance.

However, this view on the effects of geographical proximity on innovation has been highly criticized over the last few years. Some researchers question whether spatial proximity is a prerequisite for successful collaboration and knowledge exchange, and propose that other relational characteristics are more important (KNOBEN and OERLEMANS, 2006). In this regard, there is evidence that temporary geographical proximity (TORRE, 2008) and high levels of organizational

(Knoben *et al.*, 2008) or social proximity (Breschi and Lissoni, 2009) can negate the need for geographical proximity in IOLs for successful knowledge exchange. Moreover, some scholars have argued that maintaining predominantly local IOLs could lead to a lock-in situation (for example, 'group-think' and knowledge redundancy) in which firms are less open to opportunities and resources outside of their own region (Boschma, 2005; Giuliani, 2005). Finally, some authors argue that there is no reason to assume that nearby firms will be the most suitable partners or that all required knowledge is available within their own region (Rosenkopf and Almeida, 2003; Bathelt *et al.* 2004). These lines of reasoning could lead to the conclusion that sets of IOLs with both local and non-local ties would lead to higher innovative outcomes as compared with geographically local ones, because a higher level of geographical variety prevents spatial lock-in and allows firms to select the most suitable partners accessing valuable knowledge, regardless of whether they are located inside or outside the region in which the firm is located.

It seems possible, however, to combine the insights put forward by the two lines of reasoning presented above. In order to do so, the type of innovation is a highly relevant dimension to take into account. Often the type of innovation is depicted on a scale ranging from incremental to radical, on which radical stands for paradigmatic technological change impacting on and changing large parts of the economy. For two reasons, such an approach is not very applicable when doing firm-level research. First, the generation of truly radical innovations is extremely rare; therefore, using this definition would lead to the absence of observations at one end of the scale. Second, this definition takes an 'objective' macro perspective in which external experts have to determine the type of innovation and its economic and social importance, which basically makes it not feasible when conducting large-scale firm-level research. In most firm-level research, therefore, the type of innovation is based on whether the products and/or services are: (1) improved versions of products that the firm already produced; (2) products that are new to the firm; or (3) products that are new to the market.

For incremental types of innovation, maintaining predominantly local IOLs could be a worthwhile strategy, because such innovations do not cause severe internal knowledge deficits and less specialized and unique external knowledge is required. Therefore, there is a higher probability that actors in the local environment possess the required knowledge. It is less likely, however, that all knowledge required to generate more radical types of innovation will be available within the own region. More radical types of innovation cause more severe internal knowledge deficits and a need for more specialized, diverse or unique knowledge. In order to gain access to specialized knowledge required for such types of innovation, it can be argued that it is most beneficial to maintain a geographically diverse set of IOLs (Knoben, 2009). In this perspective, there is some evidence that firms with combinations of local and non-local IOLs experience the highest levels of radical innovative performance (Arndt and Sternberg, 2000; Giuliani and Bell, 2005; Graf, 2011; Sternberg and Arndt, 2001) because in this way they can develop relatively unique propositions in the market. Based on these insights, the following working hypotheses can be posed:

H1: The more geographically localized the set of direct knowledge links a firm maintains, the higher its incremental innovative performance.

H2: The higher the geographical variety of the set of direct knowledge links a firm maintains, the higher its radical innovative performance.

CONFIGURATIONS OF INTER-ORGANIZATIONAL KNOWLEDGE LINKS AND INNOVATION

Innovating firms can maintain IOLs with different types of actors in order to gain access to resources that help to generate innovations. Links with lead users/buyers can provide important information for new products or services or on how to improve them further (von Hippel, 1988), whereas suppliers can be a source of knowledge and information for process innovations leading to product quality improvements and cost reduction. Research laboratories and universities often are sources of fundamental knowledge, as is shown for the biotechnology sector (Zucker *et al.*, 1998). Competitors are knowledge sources for those firms that are in an imitation mode or use such links to monitor their markets (Park and Russo, 1996), whereas consultants can offer important market information or advice on how to improve products, services and processes (Tether and Tajar, 2008).

Instead of asking the question what type of ties provides more or better access to such resources or whether having many ties is preferable over having fewer ties, a configurational approach focuses on the question which combinations of types of ties with different types of actors are utilized by firms. The notion of a configuration of IOLs requires, for the purpose of this paper, some elaboration.

A configuration denotes 'any multidimensional constellation of conceptually distinct characteristics that commonly occur together' (Meyer *et al.*, 1993, p. 1175). In the context of IOLs, configurations refer to, for example, patterns of combinations of relations or ties with different types of actors with different intensities (Gemuenden *et al.*, 1996). The configurational approach builds on the extensive case study work by Uzzi (1996) but goes beyond the distinction between embedded ties and arm's-length ties and focuses on tie depth and the types of actors with whom IOLs are maintained. In other words, the focus is on configurations of ego-networks in which structural (actor diversity) and relational characteristics (tie depth) are taken into account.

The core idea of the configurational approach in an inter-organizational context is that different firms maintain different sets of IOLs, in terms of both the type of actors with whom they interact (actor diversity) and the depth of these links. As a result, different configurations of IOLs are expected to yield different outcomes in terms of the innovative performance of the focal firms (LAVIE, 2007).

Several theoretical arguments can be found in the literature that ground the relationship between actor diversity, tie depth and innovation. First, if a focal actor relies on inter-organizational links with actors of the same type, there are no mechanisms for iterative and diverse learning feedback with respect to an innovation (RUEF, 2002). In this argument actor diversity functions as a sounding board for the innovating focal actor. Second, having inter-organizational links with a diverse set of actors implies access to a complementary and diverse set of assets (FAEMS *et al.*, 2005). This diversity in external resources lowers the risk of information redundancy, so (really) new knowledge and information are acquired, which increase innovative performance (DUYSTERS and LOKSHIN, 2011). Moreover, diversity in their IOLs allows firms to exploit synergetic effects between different types of actors, effectively resulting in economies of scale and scope, resulting in higher levels of innovative performance (BAUM *et al.*, 2000).

For successful innovation, however, just having links with a wide range of actors is not sufficient; it also requires drawing knowledge from these sources. In other words, a flow of knowledge and information to the focal actor has to occur as well. Given the fact that the concept of IOL or tie depth is defined as the intensity with which firms draw resources from different types of actors, it is expected that firms which draw deeply from external sources are more innovative. In short, intensively interacting with a more diverse set of actors might encourage the transfer of important and new knowledge and information, which, when productively combined with internally available knowledge resources, could lead to the creation and development of processes and products that would otherwise be difficult to mobilize and develop (GOERZEN and BEAMISH, 2005). Acquiring knowledge through these diverse and deep ties enables firms to develop new or improved products/services that have value-adding features for users.

Based on these arguments, it would be expected that the more different types of IOLs a firm maintains (that is, the more diverse its configuration of IOLs), and the deeper these IOLs, the better its access to different types of knowledge, resulting in higher innovative outcomes (LAURSEN and SALTER, 2006). This line of reasoning leads to the following working hypothesis:

H3: The more an innovating firm is embedded in a diverse and deep set of direct inter-organizational knowledge ties, the higher its innovative performance.

However, not all types of innovation are equally affected by the depth and diversity of a firm's IOL configuration. Deep IOLs are often argued and found to be especially valuable for firms that develop more radical types of innovations (LAURSEN and SALTER, 2006; POWELL *et al.*, 1996). For incremental types of innovation shallow ties that perform the aforementioned sounding board function might be sufficient. For more radical types of innovation deeper ties are likely to be required, because the transfer of the (tacit) knowledge required for radical innovations erases existing communication codes which raises the need for frequent and intense interactions (LAURSEN and SALTER, 2006; LUNDVALL, 1992).

Regarding the other dimension of IOL configurations, highly diverse sets of IOLs can be argued to be most conducive to incremental types of innovation, because the very novel types of knowledge required for radical types of innovation are only possessed by a limited number of actors, such as universities or lead users (LAURSEN and SALTER, 2006). Empirical research provides several examples of this. RIGGS and VON HIPPEL (1994) showed that a majority of innovations in the scientific instruments industry came from lead users, whereas innovations in the biotechnology sector are mainly triggered by university research (HALL and BAGCHI-SEN, 2007).

Based on the above, it is expected that in the case of radical innovation firm use a few resources intensively (lower diversity combined with higher tie depth). For more incremental innovation, it is expected that a more diverse set of external knowledge sources is important but less intensively used. Therefore, the following working hypothesis is posed:

H4: Higher radical innovative performance is reached by firms embedded in configurations of less diverse but deeper direct IOLs, whereas higher incremental innovative performance is reached by firms embedded in configurations of diverse but shallower direct IOLs.

Below, the hypotheses will be put to the test by identifying the existing configurations of IOLs, exploring to what extent these configurations are geographically localized, and by using both the configuration and its level of localization to explain the innovative performance of firms.

DATA AND METHODOLOGY

The theoretical ideas put forward in the above will be explored using data from the South African Innovation Survey 2001 (SAIS2001). The SAIS2001 questionnaire was based on the European Community Innovation Survey, but adapted to the South African context

(Oerlemans *et al.*, 2006). The population of firms in the survey consisted of all South African firms in manufacturing, services and wholesale with ten or more employees that conducted economic activities in the period 1998–2000. This lower limit is used because non-response levels are often very high among very small firms. As a sampling frame the Reedbase Kompass database (August 2000 version) was used. This database contains 16 931 South African firms with a known number of employees. In SAIS2001 stratified sampling was used as the sampling technique. The population of South African firms was divided into three different size classes (strata). Taking the number of employees as an indicator of the size of a firm, the following three strata were distinguished:

- Stratum 1: firms with eleven to twenty employees.
- Stratum 2: firms with twenty-one to fifty employees.
- Stratum 3: firms with more than fifty employees.

The survey was mailed to, in total, 7339 firms, of which 8.4% returned the survey. This is a low figure, but not uncommon for organizational research, which often yields relatively low response rates (Baruch, 1999). Nevertheless, the fact that a large group of firms did not respond raises the question whether or not the data might suffer from sample bias. Therefore, a telephone non-response analysis among 462 firms was conducted. Questions were asked about specific reasons not to respond and about some firm characteristics, such as, for example, research and development (R&D) activity. The response to the non-response survey was very high (90%). Amongst others, non-responding firms were asked whether they had technological innovations in the period 1998–2000 and with what frequency they conducted R&D. As the same information was gathered in the written questionnaire as well, a comparison of the response and the non-response groups could be made. For the results of this comparison, see Table 1. As can be derived from Table 1, the comparison between respondents and non-respondents revealed no statistically significant differences.

To substantiate further the representativeness of the data, population estimates of the survey were compared with estimates produced by Statistics South Africa. All estimates based on the SAIS database were very close to the population estimates. In particular, the population estimate of the yearly growth of employment in the period 2000–2003 is 1.2%. This is exactly the same figure as the estimate provided by Statistics South Africa. These results give the authors reason to believe that the external validity of the results is high. Based on the non-response analysis and the comparison of population estimates, the response group can be considered as representative of the total population of South African firms, which implies that the data are likely to be unbiased despite the relatively low response rate.

Ultimately, this database contains information on 617 firms. In this research, (the IOL configuration of) a subset of 400 firms will be analysed. This subset has been created by selecting only firms that reported conducting innovative activities (not necessarily successful). These firms were not necessarily engaged in IOLs. Only firms with innovative activities were selected because all the theoretical mechanisms discussed above use the need to acquire (control over) resources for innovative activities as a main driver of the formation of IOL configurations. Firms that do not conduct any innovative activities are unlikely to be influenced by these mechanisms and are therefore excluded. The choice to include firms with innovative activities but without IOLs was made as previous research has shown that there is a group of innovators that 'go it alone' (Baum *et al.*, 2000). This implies that there is an 'empty' IOL configuration, which will serve as a reference group.

Measurements

To operationalize a firm's innovative performance, self-reported measures of innovativeness that were developed for the Community Innovation Survey (CIS) were used. First, managers of firms were asked whether or not their firms had introduced new or improved products or services in the previous three years (1998–2000). A three-year period was chosen to avoid a strong bias resulting from measuring accidental innovation. For firms that indicated to have done so, their innovativeness was determined by asking what percentage of the firm's turnover in 2000 was generated by these innovative products and services. The novelty of the innovations was determined by differentiating

Table 1. Non-response analysis

Variable	Respondents (%)	Non-respondents (%)	Difference (%)	Significance
Continuity of R&D activities				
More or less continuously R&D	37	40	3	
Occasionally R&D	29	29	0	0.46[a]
No R&D	34	31	−3	
Firms with technological innovations	54	58	4	0.17[b]

Notes: [a]Mann–Whitney *U*-test.
[b]Phi test.
R&D, research and development.

between three types of innovation sales, that is by turnover generated by products or services that were improved versions of existing ones, new for the firm or new to the market.

To construct IOL configurations, firms were asked to indicate for seven different types of external actors whether or not they had any IOLs with that type of actor and what the importance of IOLs with this type of actor was for their innovative activities. The possible answers ranged from zero, of no importance, to three, very important. On the basis of the responses to this question, the configuration of IOLs can be constructed in which relations with (groups of) buyers, suppliers, competitors, consultants, public research laboratories, universities, and innovation centres and sectoral institutes as well as the depth (shallow to deep) of these relations can be discerned. For descriptive statistics of these measures, see Table 2. Important to note is that this question refers to linkages maintained in the period 1998–2000, whereas the measures of innovative performance pertain to the year 2000. This lag has been introduced to capture the fact that it takes some time before the resources obtained through alliances find their way into innovative products and/or services. In this way, endogeneity problems in the analyses are reduced and reverse causality problems are dampened as well.

In order to measure the level of localization of the IOLs of a firm, firms were asked to indicate for each type of actor mentioned above where their most important partner was located. The possible response categories were: in the same town/city; in the same province; in South Africa; or outside the country. With these responses, two indicators were constructed which have been used in different model specifications, as will be discussed below. First, the total number of localized IOL partner types was calculated by computing the number of partner types located within the same province or town/city. Second, the number of localized IOL partner types was divided by the total number of IOL partner types a firm maintains to calculate the percentage of a firm's IOL partner types that are localized.

Not all regions offer the same potential to form localized IOLs. In regions with a larger pool of organizations, the likelihood of finding a suitable intra-regional knowledge source is higher. In order to control for this effect, dummy variables were included that took the value of one for firms located in one of the three main economic metropolitan areas of South Africa: Pretoria, Johannesburg and Cape Town. In 2006, these urban areas made up about 48% of the national gross domestic product.[2] Because of the high concentration of firms in these three regions, the possibilities to control for specific regional characteristics, such as the level of urbanization or specialization, are extremely limited. Therefore, this fixed effects approach was the option.

IOLs are not the only mechanism through which firms can obtain knowledge. Labour mobility and new firm formation are other knowledge spillover mechanisms that are often considered to be important in this regard (FELDMAN, 1999). To prevent a potential omitted variable bias, measures were included for both mechanisms in the analyses. For labour mobility, a self-reported importance of new personnel (on a scale from zero to three) for a firm's innovative activities was included. To control for new firm formation effects a dummy variable was included that took the value of one for firms started in the period 1998–2000.

Furthermore, a firm's internal capacity to generate and process knowledge is also likely to impact on its innovative performance because acquired external knowledge has to be processed and combined with internally developed knowledge. Therefore, the R&D intensity of a firm is used as a control by including a measure that captures the expenditures on R&D as a percentage of total turnover. This variable is also included since R&D is an important alternative source of new knowledge and a device to absorb externally acquired knowledge (COHEN and LEVINTHAL, 1990). Therefore, it is likely to influence both the propensity of a firm to form IOLs as well as its innovative performance.

Finally, several other control variables were included in the analyses. First, firm size is controlled by including the natural logarithm of the amount of full-time employees that a firm has in the analysis. This variable

Table 2. Descriptive statistics of the inter-organizational knowledge link (IOL) variables[a]

		Mean (variable range, 0–3)	SD	Bivariate correlations* 1	2	3	4	5	6	7
1	Buyers	1.03	1.04	–						
2	Suppliers	1.26	1.05	0.31**	–					
3	Competitors	1.39	0.99	0.17**	0.19**	–				
4	Consultants	0.81	0.98	0.18**	0.14*	0.07	–			
5	Public research laboratories	0.46	0.82	0.14*	0.11	0.06	0.33**	–		
6	Universities	0.49	0.84	0.22**	0.22**	0.29**	0.27**	0.48**	–	
7	Innovation centres and sector institutes	0.55	0.87	0.32**	0.15*	0.24**	0.32**	0.39**	0.42**	–

Notes: [a]Based on those observations that reported at least one IOL ($n = 276$).
*Statistically significant at the $p < 0.05$ level; and **statistically significant at the $p < 0.01$ level.
SD, standard deviation.

is included since on average larger firms maintain more IOLs and firm size is likely to influence the innovativeness of a firm as well. Second, sectoral differences are controlled by including dummy variables for service and wholesale firms (manufacturing is the reference category). Sectoral differences need to be controlled since the average level of innovativeness differs between sectors due to, among others, differences in product life cycle length. All models were also estimated using two other industry classifications, namely Pavitt dummies and two-digit Nomenclature générale des activités économiques dans les Communautés Européennes (NACE) dummies. Given the fact that both yielded identical results for the relations under scrutiny, the option was to report only the most parsimonious model. Third, dummy variables were included for multi-site firms (as opposed to single-site firms) and for South African-owned (versus foreign-owned) firms.

Tables 3 and 4 show descriptive statistics and collinearity diagnostics for all variables discussed in this section. Based on both bivariate correlations and variance inflation factors, there are no problems of multicollinearity in the data. Problems with heteroskedasticity, however, were encountered in the data when performing the analyses. Therefore, a Huber–White robust specification of the standard errors was utilized in all analyses.

Statistical techniques applied

Two different statistical techniques were used. First, a latent class cluster analysis was performed on the IOL variables to construct the IOL configurations of focal innovators. It was explicitly chosen not to incorporate the level of localization of the IOLs in this analysis because doing so would imply that certain configurations have an inherent geographical composition. It seems more likely that different firms can maintain the same IOL configuration but with different geographical compositions (Isaksen and Onsager, 2010). The approach leaves this options open.

Latent class analysis is a statistical method for finding subtypes of related cases (latent classes) from multivariate numeric or categorical data on the basis of a maximum likelihood (ML) estimation (Magidson and Vermunt, 2004). This method provides a more reliable estimation of configurations than standard cluster analysis because no assumptions about the distribution of the clustering variables are made. Whereas normal cluster analysis assumes normally distributed continuous variables, latent class cluster analysis can also deal with nominal and ordinal variables. Moreover, standard cluster analysis does not provide an objective measure to determine the number of clusters that fit the data best. In latent class cluster analysis, an ML algorithm classifies cases into clusters based upon membership probabilities estimated from a parametric model (Magidson and Vermunt, 2004). Therefore, latent class cluster analysis is highly suitable for the construction of taxonomies of multidimensional concepts, such as configurations of IOLs.

In the second part of the analysis, firm membership of a particular configuration of IOLs as well as the level of localization of the IOLs of that firm were used in regression analyses, which try to explain the innovative performance of the firm. For all three measures of

Table 3. Descriptive statistics

Variable	Mean	Minimum	Maximum	SD	VIF
Percentage sales from improved products	14.42	0	100	19.07	–
Percentage sales from products new to the firm	7.36	0	100	13.04	–
Percentage sales from products new to the market	8.96	0	100	19.81	–
CF1 – Shallow production-chain networkers	0.28	0	1	0.45	1.57
CF2 – Diverse and shallow networkers	0.22	0	1	0.41	1.88
CF3 – Shallow market followers	0.13	0	1	0.33	1.36
CF4 – Diverse and deep networkers	0.04	0	1	0.20	1.35
Number of localized IOL partner types	1.23	0	7	4.67	1.18[a]
Number of IOL partner types	4.26	0	7	2.71	1.07[a]
Percentage of IOL partner types localized	2.40	0	100	10.16	1.10
Pretoria urban area	0.08	0	1	0.27	1.11
Johannesburg urban area	0.30	0	1	0.46	1.13
Cape Town urban area	0.04	0	1	0.20	1.05
New personnel	0.59	0	3	0.91	1.54
Start-up firm	0.16	0	1	0.37	1.08
R&D intensity	4.67	0.00	81.63	9.01	1.15
Size	4.79	11	26000	1.64	1.27
Service firm	0.18	0	1	0.39	1.15
Wholesale firm	0.15	0	1	0.36	1.15
Multi-site firm	0.32	0	1	0.47	1.09
South African firm	0.83	0	1	0.38	1.08

Notes: [a]Based on the model specification as reported in Table 5. All other variance inflation factors (VIFs) refer to the specification of the model as reported in Table 6.

CF, configuration; IOL, inter-organizational knowledge link; R&D, research and development; SD, standard deviation.

Table 4. *Collinearity diagnostics*

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	CF1 – Shallow production-chain networkers	–														
2	CF2 – Diverse and shallow networkers	−0.33	–													
3	CF3 – Shallow market followers	−0.24	−0.20	–												
4	CF4 – Diverse and deep networkers	−0.13	−0.11	−0.08	–											
5	Percentage of IOL partner types localized	0.12	0.06	−0.04	−0.01	–										
6	Pretoria urban area	−0.04	0.07	0.03	0.03	−0.01	–									
7	Johannesburg urban area	0.04	−0.07	0.07	−0.02	0.09	−0.19	–								
8	Cape Town urban area	−0.04	0.08	−0.08	0.02	−0.02	−0.06	−0.13	–							
9	New personnel	0.05	0.36	−0.02	0.29	0.12	−0.01	0.01	0.02	–						
10	Start-up firm	−0.13	0.03	0.02	0.08	0.15	−0.08	0.02	0.01	0.03	–					
11	R&D intensity	0.07	0.00	0.01	−0.01	−0.03	0.13	−0.03	−0.01	0.04	−0.01	–				
12	Size	−0.04	0.23	0.01	0.11	0.10	0.07	0.00	0.03	0.26	0.05	−0.25	–			
13	Service firm	−0.04	−0.07	0.17	−0.06	0.10	0.05	0.17	0.00	0.00	0.00	0.09	−0.04	–		
14	Wholesale firm	−0.06	−0.12	−0.07	0.09	−0.06	−0.02	0.08	0.06	−0.08	0.00	−0.12	−0.12	−0.20	–	
15	Multi-site firm	−0.08	0.13	0.01	0.05	0.11	0.03	0.04	−0.03	0.08	0.13	−0.02	0.17	0.03	0.01	–
16	South African firm	0.08	−0.02	−0.19	0.06	−0.01	0.04	0.01	−0.04	0.07	0.00	0.08	−0.02	−0.01	−0.03	−0.11

Note: CF, configuration; IOL, inter-organizational knowledge link; R&D, research and development.

innovative performance by definition the score lies between zero and 100. The most appropriate method to analyse such left- and right-censored data is a Tobit analysis (GREENE, 2000). Moreover, the data for the measures of innovative performance are also highly skewed to the left. As a result, it is very likely that the assumption of a normal distribution of the residuals that is made in a Tobit analysis is violated. In order to deal with this problem, the dependent variable was log-transformed (PAPALIA and DI IORIO, 2001).

To show explicitly the impact of incorporating actor diversity and tie depth, first models are estimated with geographical variety in IOLs, but without actor diversity. Subsequently, the IOL configurations are added to show how it changes the results. Before turning to the results of these regressions, however, the outcomes of the latent class cluster analysis will be discussed.

RESULTS OF THE LATENT CLASS CLUSTER ANALYSIS

The results of the latent class cluster analysis reveal that a solution with five clusters fits the data best, as this solution yields the lowest Bayesian information criterion (BIC). The clusters incorporate 28% (117), 22% (92), 12% (51), 4% (16), and 33% (137) of all firms, respectively. In order to gain insight into the configurations of IOLs represented by these five clusters, a graph was constructed with the tie depth of IOLs on the vertical axis and the type of actor on the horizontal axis. Subsequently, all five configurations are depicted in this framework (Fig. 1).

The first configuration incorporates firms that have knowledge links with moderate levels of tie depth with buyers, suppliers and competitors, and virtually no links with other actors (relatively low actor diversity). Since this configuration represents firms that are only engaged in IOLs (vertically or horizontally) in their own value chain, this configuration is labelled as the 'shallow production chain networkers'. The second configuration consists of firms that have links with almost all types of actors (high actor diversity) with moderate levels of tie depth. This configuration can therefore be categorized as the 'diverse and shallow networkers'. The third configuration consists of firms that only maintain shallow ties with consultants and competitors (low actor diversity). This configuration is labelled as the 'shallow market followers'. The fourth configuration is made up of firms that have deep IOLs with all types of actors. Even though the depth of the IOLs differs somewhat between different types of actors, the links in this configuration are significantly deeper than in any of the other configurations. Therefore, this configuration can be labelled as the 'diverse and deep networkers'. Finally, the fifth configuration consists of firms that are not engaged in any IOLs. This configuration contains firms that 'go it alone' and are, therefore, labelled as the 'unembedded innovators'.

Table 5 depicts descriptive statistics for each of the configurations. These reveal that there is a pronounced difference in innovative performance between the 'unembedded innovators' and each of the other configurations. The differences between the other IOL configurations are, however, less pronounced and are dwarfed by their standard deviations. Regarding the level of localization, the 'shallow production chain networkers' and the 'diverse and shallow networkers' maintain on average more localized IOLs. Again,

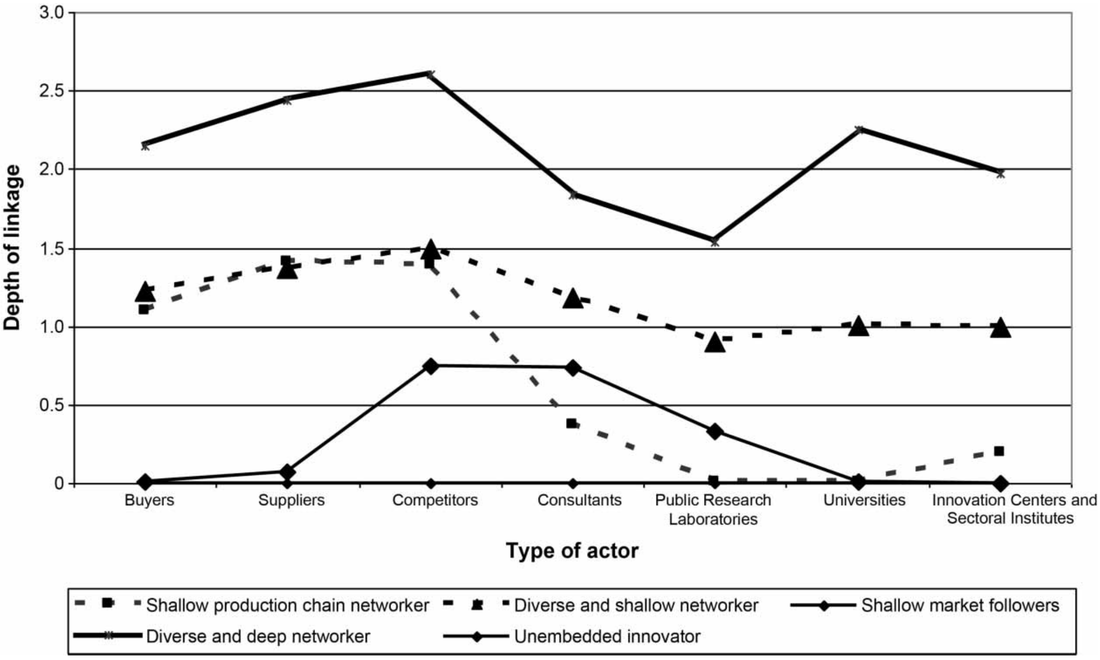

Fig. 1. Configurations of inter-organizational knowledge links (IOLs)

Table 5. Composition and characteristics of the inter-organizational knowledge link (IOL) configurations

	CF0 – Unembedded innovators		CF1 – Shallow production-chain networkers		CF2 – Diverse and shallow networkers		CF3 – Shallow market followers		CF4 – Diverse and deep networkers	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Percentage sales from improved products	3.56	11.08	19.43	19.47	22.88	20.89	14.73	15.69	24.31	26.54
Percentage sales from products new to the firm	1.94	9.04	9.58	14.45	10.61	12.37	8.45	9.62	16.56	24.68
Percentage sales from products new to the market	3.52	13.21	11.76	20.55	9.83	19.95	13.82	26.74	15.44	26.03
Percentage of IOL partner types localized	0.00	0.00	4.41	14.78	3.59	11.25	1.39	7.28	2.08	5.82
Pretoria urban area	0.06	0.24	0.06	0.24	0.12	0.32	0.10	0.30	0.13	0.34
Johannesburg urban area	0.29	0.45	0.33	0.47	0.23	0.42	0.38	0.49	0.25	0.45
Cape Town urban area	0.04	0.21	0.03	0.16	0.07	0.26	0.00	0.00	0.06	0.25
New personnel	0.00	0.00	0.66	0.90	1.21	0.96	0.54	0.95	1.87	0.89
Start-up firm	0.19	0.39	0.09	0.29	0.19	0.39	0.18	0.39	0.31	0.48
R&D intensity	3.73	9.00	5.70	10.20	4.69	7.63	5.01	9.16	4.12	6.44
Size	4.29	1.40	4.67	1.66	5.51	1.71	4.85	1.54	5.67	1.72
Service firm	0.19	0.39	0.16	0.37	0.13	0.34	0.36	0.48	0.06	0.25
Wholesale firm	0.24	0.43	0.12	0.32	0.07	0.26	0.08	0.27	0.31	0.48
Multi-site firm	0.27	0.45	0.27	0.44	0.44	0.50	0.34	0.48	0.44	0.51
South African firm	0.85	0.36	0.88	0.33	0.81	0.39	0.64	0.49	0.94	0.25

Note: CF, configuration; R&D, research and development; SD, standard deviation.

however, the difference is dwarfed by the large variation in localization within each configuration. When looking at the types of firms that maintain the different IOL configurations no clear pattern with respect to size or sector emerges. What can be said is that 'diverse and deep networkers' and the 'diverse and shallow networkers' are on average slightly larger as compared with firms with other IOL configurations. 'Shallow market followers' are often foreign owned, whereas 'diverse and deep networkers' are more often domestic firms. Finally, 'shallow production chain networkers' are often located outside the main South African urban areas and also exhibit relatively high levels of internal R&D. Despite these patterns, no IOL configuration is dominated by a single type of firm in terms of sector, size or (foreign) ownership. Moreover, all these differences are univariate. The subsequent sections will assess more systematically the relation between the different configurations and innovative performance.

IOL configurations and innovative performance

To obtain a grasp of the impact of explicitly modelling IOL configurations of actor diversity and tie depth, several models without these configurations, but with variables indicating levels of (localized) IOLs of a firm, were first estimated. As described above, three dependent variables that reflect a firm's level of innovative performance at three different levels of newness are used. Two different model specifications are estimated for each of these three dependent variables. The first specification only includes the number of localized IOL partner types of a firm. This specification is highly similar to studies that focus on a single spatial unit and only take intra-regional IOLs into account. The second specification includes both the number of IOL partner types a firm maintains as well as the percentage of these IOL partner types that is localized. This specification allows the idea that not all IOLs are necessarily localized and thereby utilizes a more elaborate conceptualization of a firm's level of spatial embeddedness, but still not taking IOL configurations into account. The results of these estimations are reported in Table 6.

The results reported in Table 6 show that the level of localization of IOL partner types matters. Specification 1 yields positive and statistically significant results for the number of localized IOL partner types except in the case of the generation of products that are new to the firm, whereas Specification 2 yields positive and highly statistically significant coefficients for the percentage of localized IOL partner types that a firm maintains for all types of innovative performance. These findings are in line with those of earlier studies with similar designs (ARNDT and STERNBERG, 2000; LEJPRAS and STEPHAN, 2008; STERNBERG and ARNDT, 2001). Also similar to earlier studies, Specification 2 provides a much better model fit as compared with Specification 1, indicating that it is important to take both localized and non-localized IOL partner types into account.

After showing that the findings of earlier TIM studies can be 'replicated', the IOL configurations are added to the models. The level of localization of a firm's IOL configuration (linear and squared) was included to address the geographical composition of a firm's IOL configuration. The results of the analyses are reported in Table 7. All models are highly statistically significant and the percentages of variance[3] explained lie between 19% and 41%, which is quite high for cross-sectional, micro-level research.

The results clearly show that the IOL configuration in which a firm is involved is heavily related to its innovative performance. For all types of innovative performance it

Table 6. Model results with geographical heterogeneity

	ln Percentage of sales from:					
	Improved products		Products new to the firm		Products new to the market	
	Specification 1	Specification 2	Specification 1	Specification 2	Specification 1	Specification 2
Constant	0.98**	−0.69	−0.47	−1.71***	0.93***	−3.35***
Number of localized IOL partner types	0.38**	–	0.37	–	1.06***	–
Number of IOL partner types	–	0.20***	–	0.15***	–	0.22***
Percentage of IOL partner types localized	–	0.04***	–	0.04***	–	0.07***
Pretoria urban area	0.91**	0.90***	0.11	0.12	1.66**	1.82***
Johannesburg urban area	0.37	0.20	−0.20	−0.32	0.05	−0.01
Cape Town urban area	0.36	0.74	0.73	1.01*	−0.96	−0.31
New personnel	0.85***	0.48***	0.73***	0.47***	0.20	−0.13
Start-up firm	−0.43	−0.01	0.06	0.31	0.78	1.21**
R&D intensity	0.02	0.02*	0.01	0.01	0.05**	0.06***
Size (ln)	0.03	0.01	0.07	0.06	−0.04	−0.06
Service firm	−0.36	−0.13	−0.11	0.02	−0.27	−0.16
Wholesale firm	−1.39***	−0.79**	−1.20***	−0.78*	−0.38	0.17
Multi-site firm	−0.08	−0.06	0.44	0.48*	0.38	0.41
South African firm	−0.53*	−0.60**	−0.30	−0.35	−0.40	−0.40
Significance	0.000	0.000	0.000	0.000	0.001	0.000
McKelvey and Zavoina's Pseudo R^2 (%)	17.7	37.1	10.9	18.3	8.0	14.2
Sigma	2.17	1.84	2.41	2.26	3.38	3.17
n	400	400	400	400	400	400

Notes: IOL, inter-organizational knowledge link; R&D, research and development.

Significance levels are based on a Huber–White robust specification of the standard errors. *Statistically significant at the $p < 0.10$ level; **statistically significant at the $p < 0.05$ level; and ***statistically significant at the $p < 0.01$ level.

holds that firms that are involved in IOLs are better off compared with firms that 'go it alone'. However, the magnitude of the relation with innovative performance differs considerably between the IOL configurations. With regard to the generation of sales by improved products (incremental innovations), the 'shallow production-chain networkers' and the 'shallow and diverse networkers' configurations have a significantly larger relation than the other two configurations. The more radical the types of innovative performance become, the smaller the differences between the configurations.

Interestingly, even though its impact is positive on all types of innovative performance, being a 'diverse and deep networker' is relatively weakly related to a firm's innovative performance. Apparently, this configuration with relatively high levels of actor diversity and tie depth does not yield any benefits that cannot be obtained through shallow networking or simply by using the knowledge links to buyers, suppliers and competitors. A possible explanation for this finding lies in the fact that the relation between innovativeness and deep ties is moderated by the density of relations between the focal firm's partners (ROWLEY *et al.*, 2000). The underlying argument is that strong ties and ego-network density are substitutes because both lead to higher trust levels and the establishment of behavioural norms (COLEMAN, 1988). As a result, the impact on performance is highest when an ego-network is based on deep ties or density, but not on both. As the data do not capture the density of ties between the focal firm's partners, this unobserved moderation effect might explain the relatively modest impact of this particular configuration on a firm's innovative performance.

There is no indication that more diverse types of IOL configurations have a positive impact on a firm's innovative performance as compared with less diverse configurations. Even though the two configurations with relatively high levels of actor diversity have a positive relation with a firm's innovative outcomes, the less diverse configurations, and the 'shallow production-chain networker' in particular, yield similar or even higher coefficients. Therefore, even though being involved in configurations of knowledge links is clearly positively related to a firm's innovative performance, working Hypothesis 3 is rejected.

The relation with the different IOL configurations becomes weaker as the type of innovations becomes more radical, whereas an alternative source of new knowledge, internal R&D, becomes more important. Therefore, conducting one's own research remains vital in order to generate products that are new to the market (STERNBERG and ARNDT, 2001). Moreover, there is no real indication in the results that less diverse IOL configurations with relatively high levels of tie depth are more beneficial for more radical types of innovation. Therefore, Hypothesis 4 is rejected as well.

With regard to the role of geography in IOL configurations it is found that maintaining a local IOL

Table 7. Model results with inter-organizational knowledge link (IOL) configurations and geographical heterogeneity

	ln Percentage of sales from:		
	Improved products	Products new to the firm	Products new to the market
Constant	−0.65	−2.36***	−3.20***
CF1 – Shallow production-chain networkers	0.54***	0.40***	0.33***
CF2 – Diverse and shallow networkers	0.55***	0.45***	0.31***
CF3 – Shallow market followers	0.35***	0.34***	0.24***
CF4 – Diverse and deep networkers	0.27***	0.25***	0.23***
Percentage of IOL partner types localized	−0.30	−0.63	0.32
CF1 * percentage of IOL partner types localized	0.31	0.65	−0.27
CF2 * percentage of IOL partner types localized	0.12	0.59	−0.33
CF3 * percentage of IOL partner types localized	0.05	0.46	−0.36
CF4 * percentage of IOL partner types localized	0.09	0.86	−0.78**
Percentage of IOL partner types localized squared	0.02	0.02	−0.01
CF1 * percentage of IOL partner types localized squared	−0.02	−0.02	0.01
CF2 * percentage of IOL partner types localized squared	−0.02	−0.02	0.02
CF3 * percentage of IOL partner types localized squared	−0.02	−0.01	0.02
CF4 * percentage of IOL partner types localized squared	−0.02	−0.03	0.15
Pretoria urban area	0.74*	−0.06	1.64**
Johannesburg urban area	0.25	−0.34	0.09
Cape Town urban area	0.36	0.75	−1.23
New personnel	0.16	0.05	−0.46**
Start-up firm	−0.06	0.31	1.02**
R&D intensity	0.01	0.02	0.04**
Size	−0.08	−0.03	−0.19
Service firm	−0.15	−0.03	−0.30
Wholesale firm	−0.85***	−0.75**	−0.08
Multi-site firm	−0.20	0.26	0.21
South African firm	−0.26	0.15	0.04
Significance	0.000	0.000	0.000
McKelvey and Zavoina's Pseudo R^2 (%)	40.8	26.9	18.7
Sigma	1.74	2.07	3.02
n	400	400	400

Notes: CF, configuration; R&D, research and development.

Significance levels are based on a Huber–White robust specification of the standard errors. *Statistically significant at the $p < 0.10$ level; **statistically significant at the $p < 0.05$ level; and ***statistically significant at the $p < 0.01$ level.

configuration does not influence a firm's innovative performance beyond the effect resulting from being a member of that IOL configuration. The only exception is the 'diverse and deep networker' and the generation of sales with products that are new to the market. For this particular case, maintaining predominantly local ties has a negative relation with innovative performance. This result stands in sharp contrast to what is generally advocated in the TIM literature, where it is argued that maintaining deeply localized knowledge links is beneficial to (more radical) innovation. In line with theoretical ideas that criticize this view (BOSCHMA, 2005) and recent empirical evidence from the social network literature (MOLINA-MORALES and MARTÍNEZ-FERNÁNDEZ, 2009), the findings point in an opposite direction and show that high levels of spatial embeddedness have negative implications.

The variety in the localization of IOLs, reflected in the combination of the normal and squared effect of the localization variable, has no significant relation with a firm's innovative performance. These results indicate that there is no single geographical IOL composition that goes together with superior innovative performance for the focal firm. Even for the most radical type of innovative outcome, which is often argued to require highly tacit knowledge and therefore face-to-face contacts and localized IOLs, maintaining local IOLs does not yield higher levels of innovative performance.

All in all, the impact of the geographical distribution of the IOL configuration of a firm is negligible or even negative compared with the effect of the configuration itself. Consequently, working Hypotheses 1 and 2 are rejected after including the IOL configuration of innovating firms. This lack of results regarding the spatial dimension of the IOL configurations might seem puzzling, because several earlier studies with similar designs have found significant positive effects. In this regard, it is important to note that the IOL configurations differ in their level of localization. The 'shallow production-chain networker' is, on average, the most localized configuration, followed by the 'diverse and shallow networker'. The 'shallow market followers' and the 'diverse and deep networker' are the least localized IOL configurations. This ordering seems logical because many, especially small, firms operate primarily in local markets, and therefore primarily have local buyers, suppliers and competitors. The same does not necessarily hold for knowledge institutes such as universities and public research laboratories. Such organizations are often more geographically dispersed, making it less likely that a firm can tap into them as a local knowledge source. In other words, the geographical distribution of their IOL configuration represents the prevalence of potential partners at different geographical distances. As a result, the fact that the diversity of actors within an IOL configuration are explicitly taken into account also captures part of the variety in their spatial distribution.

The differences between the results reported in Tables 6 and 7 imply that it is highly important to take actor diversity in IOL configurations into account. In short, the results show that when controlling for combinations of actor diversity and tie depth, the differences in spatial distribution are no longer related to a firm's innovative performance. As such, it seems likely that the results of the earlier studies are biased due to unobserved actor diversity and the systematic relation of this diversity with the spatial distribution of actors. This applies equally to studies that focus on single (successful) spatial units and IOLs therein as to studies that analyse the impact of both local and non-local IOLs but do not control for the type of actors with whom these IOLs are maintained.

DISCUSSION

This research set out to provide a classification of configurations of inter-organizational knowledge links (IOLs), their geographical composition, and explore the relation between these configurations and the innovative performance of firms. The findings indicate that, when excluding IOL configurations based on actor diversity and tie depth, geographical proximity in IOLs matters. Having more local partner types is associated with higher levels of innovative performance. When incorporating the diversity of types of actors with whom IOLs are maintained and the tie depth of these links, the results change drastically. First, it is shown that IOL configurations are highly related to a firm's innovativeness. Therefore, a 'going-at-it-alone' strategy is not very beneficial to firms striving to be innovative, which shows the empirical validity of the extended version of the resource-based view of the firm (Lavie, 2006) for the study of innovation. Second, it is shown that it is not geographical proximity as such, but rather diversity in the types of actors with whom a firm maintains direct IOLs and variation in tie depth that impact on its innovative performance. These configurations capture part of the geographical composition of a firm's IOLs, because regions offer different opportunity structures in terms of available partner types. It has been shown empirically that after controlling for this effect, the level of geographical proximity of a firm's IOL configurations has a negligible or even negative relation with innovative performance.

These findings echo the results of earlier research into the importance of geographical proximity in other contexts, such as knowledge spillovers. Breschi and Lissoni (2009), for example, found that the importance of geographical proximity in patent citations is largely driven by the social relations between, and the mobility of, researchers. Both in their research as well as in the present results, the importance of geography is driven by the fact that the relevant actors are not randomly distributed in geographical space. The selection of partners therefore leads to an endogenous geographical distribution which, if the underlying cause is not explicitly taken into account, leads to the erroneous conclusion that geographical distance itself matters for the outcome variable under scrutiny.

The findings have strong implications for the theoretical lines of reasoning underlying territorial innovation models (TIMs). First, the sole focus of TIM studies on spatially proximate IOLs leads to biased results. Some IOL configurations, notably the 'innovation follower' and the 'shallow production-chain networker', are on average more geographically concentrated than others. When only studying intra-regional IOLs, such configurations are likely to be over-sampled and their impact overestimated. Therefore, the TIM literature should pay more attention to the role of inter-regional IOLs rather than focusing on intra-regional IOLs only (Bathelt *et al.*, 2004).

Second, it is important to take into account the different types of actors with which firms maintain relations. The fact that firms are located within the same area does not necessarily imply that they interact. Given the fact that the results clearly show that the sets of IOLs in which a firm is embedded have a substantial influence on the innovative performance of the firm, it seems logical to try and incorporate these notions in future TIM studies.

In general, it is argued that TIM studies can be enhanced both in terms of internal validity as in terms of explanatory power by shifting the level of analysis from the region to the firm and its IOL configuration. Doing so implies focusing less on the territorial part of the TIM concept and more on the types of actors that are present in a territory and how (deep) these actors are linked to each other. In other words, the composition of actors in a region and the linkages between firms inside and outside that region deserve more attention in the TIM literature at the expense of the focus on the region as such. Making this shift still allows for a study of regional differences, yet it also makes it possible to take the diversity in IOLs of firms into account which this research has shown is of great importance for the innovative performance of firms.

LIMITATIONS AND DIRECTIONS FOR FUTURE RESEARCH

Besides the contributions of this research, several limitations apply. First, the operationalization of IOLs does not allow individual IOLs to be identified, but only the aggregated existence of IOLs with certain types of actors. Moreover, at this aggregated level, there is only information regarding the tie depth of IOLs with these actors, which is only one of the relevant dimensions of inter-organizational relationships distinguished when studying innovation in the literature. This approach, which is adopted from the European Community Innovation Survey and has been used in earlier research by others as well by LAURSEN and SALTER (2006), was applied because the data-collection problems become exceedingly large when firms are asked about the characteristics of more than one IOL. In order to be able to collect large-scale data and, thereby, derive more externally valid results, the research approach discussed above was chosen. Nevertheless, replication with more detailed ego-network data seems a fruitful next step in this kind of research. One could, for example, take other relational characteristics into account such as organizational trust and reciprocity.

Second, the existence of nation-specific aspects to the innovation process and institutions leads to the conclusion that there are limitations to the extent in which county-specific findings can be generalized to other contexts (LUNDVALL, 1992). In the specific case of South Africa, previous research (BLANKLEY and KAHN, 2005) showed that the South African system of innovation is in an imitation mode. This state of affairs is described as South Africa being a technology colony: product and processes are improved using imported and imitated, most often foreign, technological knowledge, with large parts of the revenues flowing to companies outside South Africa. In this imitation mode, firms are less likely to collaborate with organizations that develop new knowledge such as universities and public research institutes. This tendency might be reflected in the data by the relatively low proportion of firms that report links with universities or other research institutes. As a result, it is unclear whether the findings presented in this study will hold in highly developed and industrialized regions and economies. Nevertheless, the fact that the authors could ‘replicate’ the findings of earlier Western research and are thereby explicitly show the effects of controlling for actor diversity in a firm’s IOLs allows a strong and robust argument to be made in favour of controlling for actor diversity is this type of research.

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NOTES

1. In this study an egocentric network consists of a focal organization and its partners (direct ties). Even though this is the most prevalent definition of an egocentric network, the partners of the partners (indirect ties) are sometimes included in egocentric network studies as well.
2. *Source:* Statistics South Africa.
3. McKelvey and Zavoina’s Pseudo R^2 is reported because this measure closely represents the R^2 yielded by an ordinary least-squares (OLS) estimation in terms of interpretation.

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